RACING TO KEEP UP

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ABSTRACT

The preparation of secondary mathematics teachers for today's technology rich classroom environment is a continually evolving process. Mathematics teachers are expected to demonstrate the ability to incorporate a variety of instructional strategies and technological tools as well as multiple assessment techniques in their teaching. Classroom technology options have expanded from the once innovative graphing calculators and data-collection devices to include more all-inclusive software packages, graphics, video clips, digital images, and more. The confluence of an increased number of technology options, stronger technological background of today's students, and the expectation that mathematics teachers demonstrate content knowledge as well as the ability to incorporate a variety of instructional strategies, technological tools, and multiple assessment techniques in their teaching finds teacher preparation institutions constantly updating their programs. This paper examines the current state of technology preparation of pre-service teachers and presents one university's approach for updating the technological readiness of pre-service secondary mathematics teachers. This update includes a description of how varied technological tools are employed in developing and assessing mathematical understanding.

Key words: teacher education, technology, assessment

1. Introduction

Preparing secondary mathematics teachers for today's technology rich classroom environment is a continually evolving process. Classroom technology options have expanded from the commonly used graphing calculators and data-collection devices to include more all-inclusive software packages, graphics, video clips, digital images, and more. The confluence of an increased number of technology options, stronger technological background of today's students, and the expectation that mathematics teachers demonstrate content knowledge as well as the ability to incorporate a variety of instructional strategies, technological tools, and multiple assessment techniques in their teaching finds teacher preparation institutions scrambling to update their programs. This paper examines the current state of technology preparation of pre-service teachers and presents one university's approach for updating the technological readiness of pre-service secondary mathematics teachers. This update includes a description of how varied technological tools are employed in developing and assessing mathematical understanding.

2. Status of Pre-service Teachers' Technology Preparation

Technology has profoundly affected how people live and work in today's global and digital economy. It has changed what students need to know and be able to do in order to be successful. Tapscott (1998) asserts that today's students are "growing up digital." Unprecedented access to information and ideas across real-time, web-based, interactive media has spurred societal changes in ways that previous technologies have not. According to Ruskoff (1996), students are natives to cyberspace; the rest of us are immigrants. Despite this characterization of students as technology-savvy, most pre-service teachers know very little about effective use of technology in education. Students have access to computers and technology skill development courses, but they have little experience with the application of technology in teaching and learning.

Student learning is enhanced by technology utilization in the following ways: (a) real-world contexts; (b) connections to outside experts; (c) visualization and analysis tools; (d) scaffolds for problem solving; and (e) opportunities for feedback, reflection, and revision (Bransford, 1999). With the emergence of new technological tools, many teacher preparation programs emphasize the active engagement of students in learning and doing mathematics through the use of real-world contexts. Modeling and solving problems based on real-world situations is more accessible as a result of e-mail contact with outside experts, as well as the computational and graphical capabilities that technology provides. The process of developing a model for the problem situation, obtaining feedback, revising the model, and reflecting on the process and product is less cumbersome when technology is employed. It is technology that offers many powerful tools for constructing a mathematical foundation that supports how children and adults learn and do mathematics (Dunham & Dick, 1994; Sheets, 1993; Rojano, 1996).

A number of surveys and reports from the late 1990's conclude that although teacher training programs have increased technology utilization, technology is not well integrated into the college classroom (National Council for Accreditation of Teacher Education, 1997; Persichitte, Tharp, & Caffarella, 1997; President's Committee of Advisors on Science and Technology, 1997). Moursand and Bielefeldt (1999) report that although technology skills of college faculty are comparable to the technology skills of their students, most faculty do not model the use of instructional technology in their teaching. Students' exposure to coursework utilizing technology is

generally not tied to curriculum, instructional methods, field experience, or practice teaching. Numerous studies indicate that the instructional methods employed when teaching a pre-service teacher are important factors in shaping the pre-service teacher's instructional delivery and assessment practices (Rahal & Melvin, 1998; Raymond, 1997; Stanford, 1998; Wilcox, Schram, Lappan, & Lanier, 1991). Teachers teach as they are taught. Despite this, pre-service teacher education, is not adequately preparing educators to work in a 21st century technology-enriched classroom.

The disparity between the actual versus the desirable technology-based instructional skills possessed by recent teacher education graduates is often large. Focusing attention on understanding and minimizing this disparity, the 1998 Milken/International Society for Technology in Education (ISTE) survey on instructional technology in teacher education identifies four essential components for the instructional technology preparation of new teachers: (a) facilities for students and teachers, including Internet access, classroom arrangement, numbers and technical features of computers, technical support, and continuing funding; (b) integration of technology in learning, including faculty modeling of instructional technology usage, project-based learning and problem-solving situations, computer-assisted instruction, and experiences in varied classroom technology configurations; (c) student ability to use applications including word processing, e-mail, web browsers, and electronic grade books; and (d) field experience opportunities where instructional technology is available and actually used and with supervisors and master teachers who can model and advise on classroom technology use (Bielefeldt, 2001). Released two years later, the ISTE National Educational Technology Standards for Teachers (ISTE NETS) provide teacher education programs in the United States with comprehensive guidelines for assessing the technological preparation of pre-service teachers (ISTE, 2000). The teacher education program accreditation process offers the greatest prospect for assessing the full impact of these standards.

3. A Course for Updating Pre-service Teachers' Technological Readiness

At North Georgia College & State University (NGCSU) a major component of the effort to address the technological preparation of pre-service secondary mathematics is a course entitled Technology in Mathematics. This course combines technology-related content, pedagogy, and assessment. Students receive direct instruction on graphing calculators that includes the TI-83 Plus, TI-89, and TI-92 Plus; data-collection devices including the Calculator-Based Ranger (CBR), Calculator-Based Laboratory (CBL), and related probes; and software such as *Geometer's Sketchpad* (*GSP*), *Cabri*, *Fathom*, *TI-InterActive*, and *Excel*. However, the primary emphasis is on the demonstration of pedagogically sound instructional and assessment techniques. Modeling the appropriate use of technological tools in the learning and doing of mathematics is imperative as pre-service teachers experience the teaching behaviors that teacher education programs seek to develop in them.

The format of class sessions includes dialogue, hands-on activities, student presentations, and reflection on practice. The dialogue portion provides students an opportunity to discuss their perspective on the implementation of classroom activities and ideas for improvement based upon experiences with peer presentations. The hands-on activities portion includes instruction in the areas of content, technology utilization, and the assessment of student learning. The presentation portion is led by the pre-service teachers and includes content-related activities self-chosen from a

list of options. Cooperative and collaborative learning activities utilizing graphing calculators, CBR, and CBL provide a structured basis for group projects and student-led technology presentations. The reflection on practice portion includes self-assessments and reflective logs that are designed to engage pre-service teachers in a critical analysis of their teaching performance and their selection of instructional strategies, materials, and assessment alternatives.

Instruction on specific technology is couched in the context of mathematics concepts that are appropriate for use in the secondary mathematics curriculum. Although students enrolled in this course are typically in or near their last year of college, their recollection of much of secondary mathematics is sketchy. Consequently, learning to use the technology serves as a vehicle for reinforcing, and in some cases developing, mathematics concepts that they are expected to know and be able to convey when they begin their teaching internship. Even more critical is the performance of students on a nationally administered content knowledge test, the PRAXIS 2. This test also requires students to demonstrate proficiency with using a graphing calculator and is required of all prospective secondary mathematics teachers before they can acquire a teaching certificate.

Graphing calculators are used in this course for exploring concepts of number theory, data representation and analysis, probability, discrete mathematics, rates of change, and functions. Used in conjunction with data-collection devices, graphing calculators provide media through which problem solving and connections between mathematics and other disciplines, as recommended in the *Principles and Standards for School Mathematics (*NCTM, 2000) are solidified. In particular, the CBL with its microphone, voltage sensor, and temperature and light probes has breathed fresh life into how previously learned mathematics concepts connect with other subjects and how these connections can be described. Students perform experiments both inside and outside of class that involve the investigation of coefficients of friction, sound waves, pendulum motion, heating and cooling models, and light intensity relationships. They appear genuinely surprised and pleased to discover that mathematics actually relates to everyday situations. Although the "Walk the Line" CBR activity that engages students in trying to match the graph of their walk with a given graph is commonly used in mathematics classrooms spanning many grade levels, it is the first time that a significant number of these students have been forced to think about slope in terms of a physical phenomena. An even more enlightening activity for them is using the CBR to investigate the calculus of motion, specifically the derivative and definite integral. Students capture a walk that incorporates both forward and backward motion, relate the resulting curve to velocity, and then determine the area under the curve they walked. Through such hands-on experiences, pre-service teachers are convinced that the use of technology is an effective means of explaining and predicting real-world phenomena.

On-line data sites supplying real-world data that can be represented, analyzed, and interpreted provide another opportunity for engaging pre-service teachers in explaining and predicting real-world phenomena. *TI-InterActive* has proven to be a valuable software tool for developing and reinforcing algebra, data analysis, precalculus, and calculus concepts. Because it includes a web browser, computer algebra system, spreadsheet, lists, graphs, word processor, and data collection transfer capabilities in an integrated package, students find it very easy to use. Data obtained from student activities incorporating the CBR, CBL or graphing calculators such as the TI-83 Plus, TI-89, or TI-92 Plus is easily downloaded to *TI-InterActive*. Once the data is in a list, a graphical representation is created and a regression analysis completed.

Fathom is particularly well-suited and effective for developing and reinforcing statistical concepts. Students use its simulation capabilities for conducting experiments and then analyze

their results. One of the greatest obstacles that exist with students' background in statistics is their lack of true understanding of statistical concepts. Although well-versed in formulating hypotheses and conducting statistical tests, they have minimal understanding of the underlying concepts. Herein illustrates another example of where technology as an instructional tool is effective in developing deeper and more thorough conceptual understanding.

This course employs dynamic geometry programs to enhance students' experience with two- and three-dimensional geometry. Pre-service teachers complete activities that incorporate interactive geometry software such as *Geometer's Sketchpad* (*GSP*) and the TI-92's *Cabri* or *GSP* for investigating geometric concepts, making and validating conjectures, and writing paragraph proofs or justifications. Interactive geometry projects are especially effective and serve several purposes: (a) to increase student understanding of geometric concepts, (b) to actively engage students in the learning process, (c) to illustrate how the van Hiele levels of geometric thinking apply to students of all ages, and (d) to promote student enjoyment of mathematics. For pre-service secondary mathematics teachers, it is the experience of designing, selecting, implementing, and reflecting on technology-based activities that has been most effective in transferring the responsibility for learning from the instructor to the student.

Continual updating of this course is necessary as new technologies emerge. Most recently, the digital camera and the digital video recorder have been added to this course's technology arsenal. Students use digital cameras and video cameras to capture commonly occurring items and situations such as light bulbs, the path of water rising from a fountain, airplane propellers, flowers, shells, and the roofline of a building. These captured images are then used to determine an equation in function, polar, or parametric mode that models the given situation. Using this equation, concepts such as area, volume, and surface area are explored. Mathematics makes more sense and is easier to apply when connections with existing knowledge are made (NCTM, 2000). Technology facilitates the process of making connections and provides a vehicle for accessing previously inaccessible real-world applications of mathematics.

4. Assessment and Technology

Personal experience confirms the value of utilizing several formative and summative assessment techniques including presentations, reflective logs, group and individual projects, peer and self-evaluation, writing prompts, journals, and portfolios in teacher preparation programs. A key component of assessment development is the design of tasks that enable students to use and demonstrate a broad range of abilities. Activities, discussions, and student presentations are structured in a way that incrementally builds a foundation from which informed decisions relative to the selection of technological tools and developmentally appropriate instructional and assessment activities that support how children and adults learn and do mathematics can be made.

Technology-based presentations are conducted by individual students as well as by groups of students. Upon completion, student presenters prepare a one-page reflective summary describing what went well and what could be improved in future presentations. In addition, each presenter completes a self-evaluation based on a prepared rubric. Participants complete a rubric-based peer evaluation and the results are shared with each presenter.

Journals are an enlightening component of the assessment process. They provide feedback about the students' understandings, require students to explain concepts and thought processes, foster creativity and confidence, and supply a venue for students to reflect on their own learning.

The information gleaned from students' journal entries offers insight into exactly how and what students know and are able to do. Journals are a valuable tool for illuminating our practice.

Portfolios offer a means for students to self-assess their learning, to integrate what they have learned in the course, to document their intellectual growth, and to experience a process they may wish to use when they become teachers. Portfolios are also helpful to faculty in providing another source of direct evidence for what pre-service teachers know and can do. Barton (1993) identifies several strengths that portfolio usage offers teacher education programs: (a) empowerment, the shifting of ownership of learning from faculty to student; (b) collaboration, allowing students to engage in ongoing discussions about content with peers and teachers; (c) integration, making connections between theory and practice; (d) explicitness, focusing on the specific purpose of the portfolio; (e) authenticity, linking included artifacts with classroom practice; and (f) critical thinking, reflecting on change and growth over time. Portfolios are widely used in teacher education programs as a means of bringing together curriculum, instruction, and assessment. Students and teachers develop a shared understanding of what constitutes quality work. Portfolio usage leads to classrooms that are student-centered rather than teacher-centered, chiefly because students accept more responsibility for their education

Digital portfolios are quickly becoming the preferred portfolio type. The advantage of the digital portfolio lies in the broad range of technological competencies possessed by the pre-service teacher that can be captured and showcased. Possible artifacts include video and sound clips of a pre-service teacher leading a class activity, specific mathematics software and calculator proficiency demonstrations, the creation of a web page or electronic presentation, and the incorporation of digital images in a variety of media.

The culminating assessment for pre-service teachers in the Technology in Mathematics course is the creation of a digital teaching portfolio. This portfolio showcases students' proficiency with incorporating multiple technologies as instructional and assessment tools in the mathematics content area. Although the principal purpose that digital portfolios serve in the Technology in Mathematics course is evaluative, pre-service teachers report using their digital portfolio as a presentation medium when interviewing for a teaching position. A compact disc with the interviewee's documented technology skill set has become a valuable and authentic means of showcasing achievements, proficiency, and the capability to use technology to support lifelong professional development.

5. Conclusion

Mathematics teacher preparation programs face numerous challenges as they update their programs to reflect the emergence of new technologies. The teachers we prepare must have adequate mathematical and technological knowledge to provide appropriate support for today's K-12 students. Three areas for concentrated effort on the part of teacher preparation units are technological currency, instructional delivery methods, and assessment. Ensuring that the most recent tools are available for student use is a daunting and time-consuming process for faculty. Becoming an expert with each new technology is certainly not as important as modeling our willingness to be a life-long learner in search of the most effective instructional tools for the mathematics classroom. Active engagement of students in learning and doing mathematics through the use of real-world contexts is now easily achieved via technology and must become a larger and more pragmatic focus for teacher preparation efforts. Faculty must first think about students' learning in terms of actively involving them in investigating and making sense of mathematics.

The development of conceptual understanding in pre-service teachers is crucial if they in turn are to develop understanding in their students. Coupling this instructional responsibility with the need for pre-service teachers to be knowledgeable of a broad range of assessment options further complicates the process. Technology provides many unique capabilities for supporting varied forms of instruction and assessment. Increased infusion of integrated and interactive software packages, digital images, graphics, and video clips offer expanded potential for collecting information about students' performance of complex tasks and for their selection of work samples. It is important to remember that the challenges we face in preparing secondary mathematics teachers for tomorrow's technology rich classroom environment are not necessarily negative, but rather opportunities for meaningful growth on the part of faculty and pre-service teachers.

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